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GB 2140912 A GB 0969400 A GB 0615567 A
GB 0331824 A

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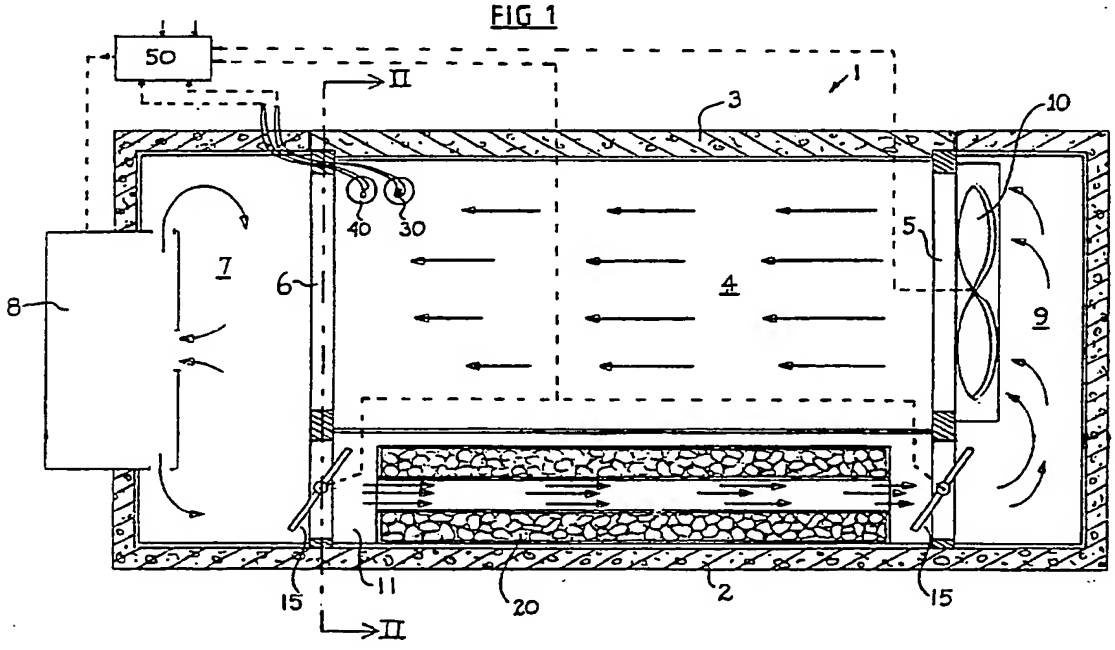
(54) Humidity control apparatus

(57) Humidity control apparatus (1) has a circulating fan (10) for circulating air through a main chamber (4) and returning it via return passage means, wherein the return passage means comprises at least a first air flow passage (11) containing moisture removing means (20), e.g. a desiccant, and a second air flow passage containing moisture adding means, the passages being arranged in parallel. Flow of the circulating air through the air flow passages is controlled by valves (15) so that moisture is either removed from, or added to, the circulating air. The moisture adding means may be water-laden fabric. The humidity control apparatus may include means (8) for resistance heating and Peltier cooling of the circulating air. The apparatus may be controlled manually or automatically in response to temperature and humidity sensors (30, 40). The apparatus may be used for testing footwear.

FIG 1



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

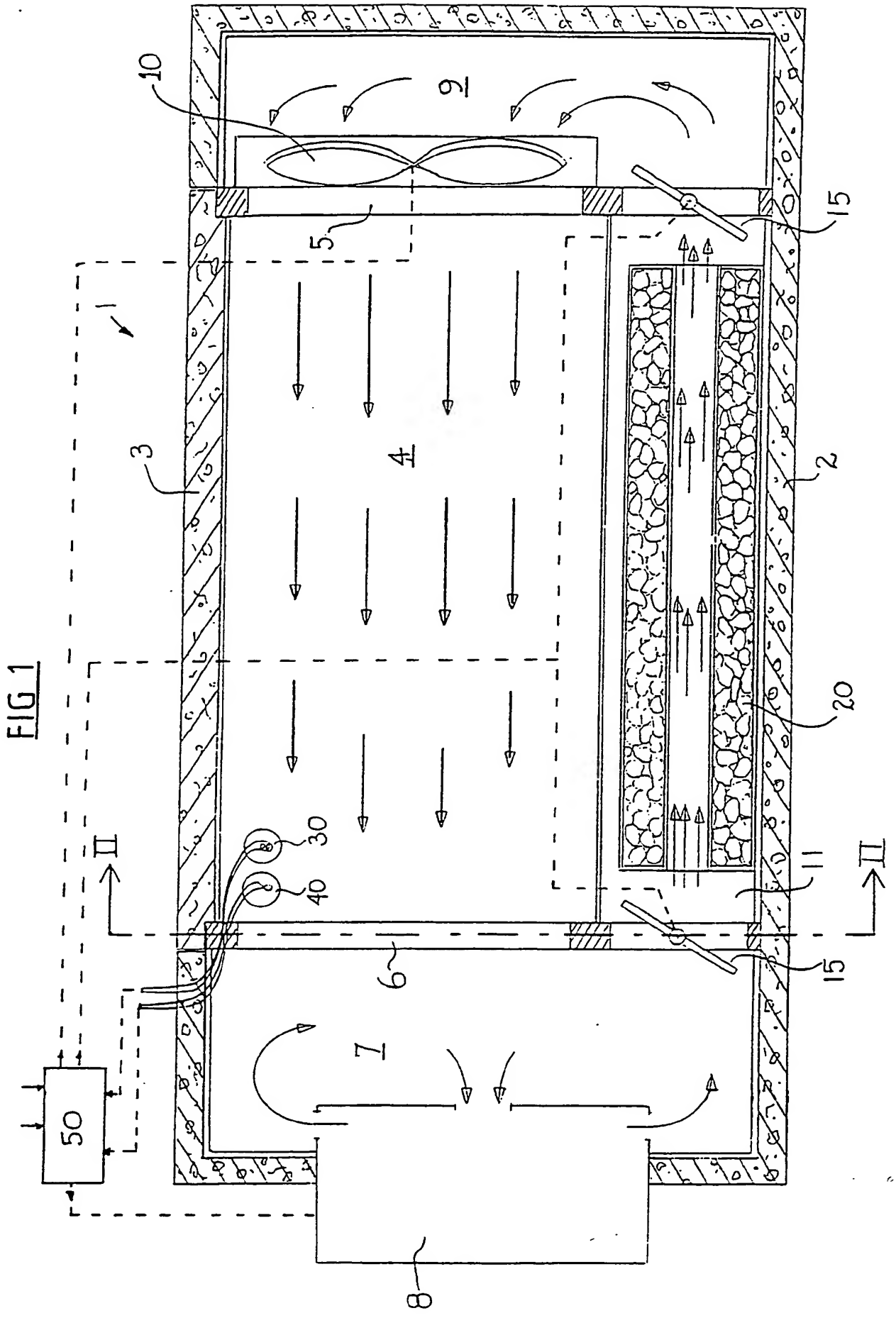


FIG 1

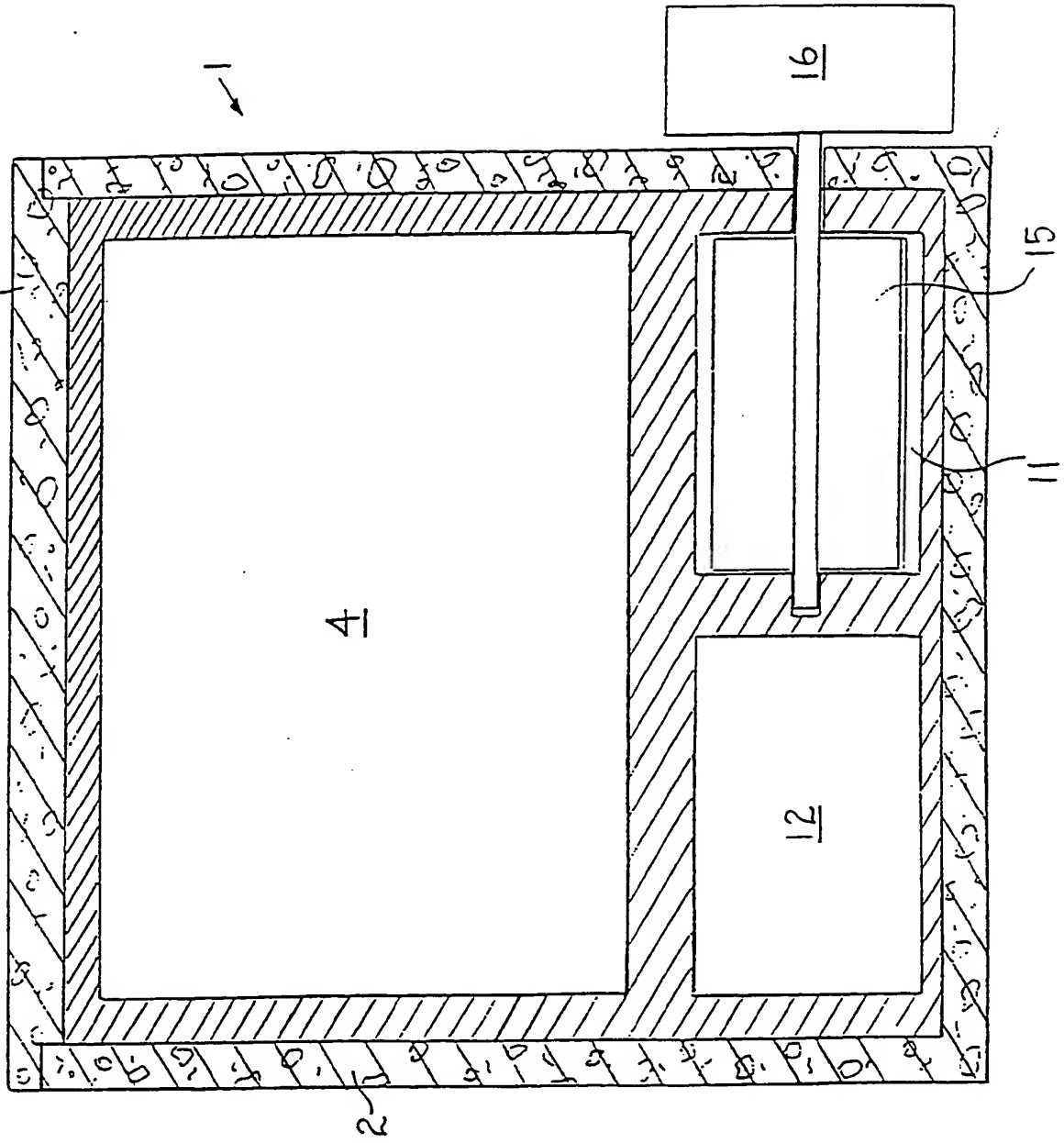


FIG 2

FIG. 3

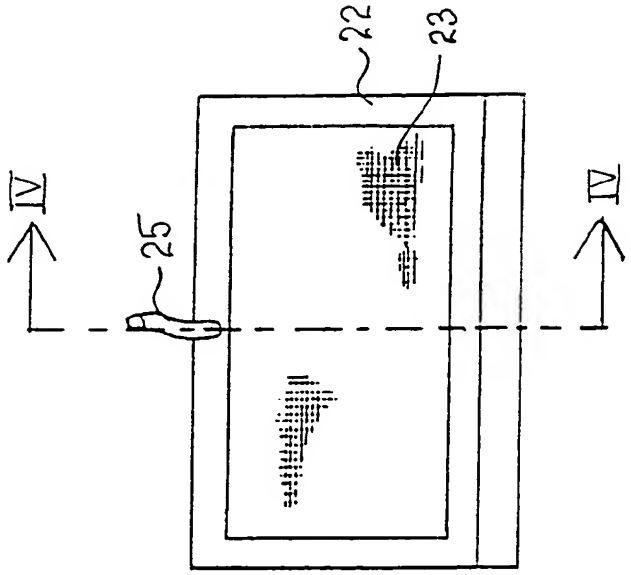
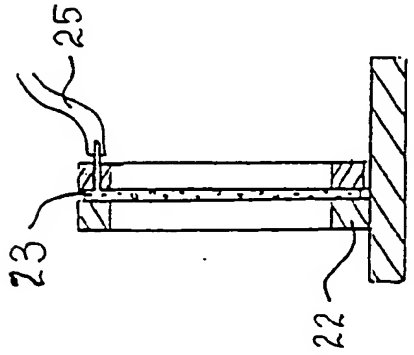


FIG. 4



Humidity control apparatus

This invention relates to humidity control apparatus including a main chamber through which air is circulated. The invention also relates to a method of testing articles, in particular footwear such as shoes, under different temperatures and humidity conditions.

Controlled temperature and humidity chambers are used for many types of research studies. In most known chambers of this type, the relative humidity in the chamber is increased by injecting into the chamber either steam or droplets of water. Steam creates problems because of the difference in temperature between the steam and the air in the chamber. It also suffers from a tendency for the water to separate from the equilibrated atmosphere because the temperature drops below the dew point. When water droplets are used, the droplets are formed either by forcing water through a small orifice at high pressure or by an ultrasonic device. Water added to a chamber in the form of droplets is not easily absorbed into the air (particularly when the humidity in the air is already high) and, as a result, it takes a very long time to obtain high relative humidities with water droplets.

When it is necessary to reduce the humidity in such chambers, most of the known apparatus in current use condense water out of the air by bringing the air in contact with a surface which is colder than the air in the chamber. The problem with this approach is that the water which is removed from the air must either be removed from the chamber or isolated from the air in the chamber to prevent it from being reabsorbed back into the air. Passing air over a cold surface, also reduces the temperature of the air and influences the relative humidity.

Many known chambers in current use also exchange air between the interior and exterior of the chamber. For some experiments it is necessary that the air within the chamber

remains totally confined to the chamber, with no air added or removed, for the duration of the test.

The present invention seeks to control the humidity of air circulating through a main chamber by adding moisture to, or removing moisture from, the air as the air is returned to the main chamber for further circulation.

According to one aspect of the present invention there is provided humidity control apparatus comprising a main chamber having an air inlet and an air outlet, return passage means connected between said air inlet and said air outlet and comprising at least first and second air flow passages arranged in parallel, circulating means for continuously circulating air through the main chamber and the return passage means, moisture removing means arranged to remove moisture from air circulating through said first air flow passage, moisture adding means for adding moisture to air circulating through said second air flow passage and valve means for controlling the flow of air through said return passage means to control the moisture added to, or removed from, the circulating air. The reference to the air flow passage being arranged "in parallel" is not intended to refer, necessarily, to a parallel relationship in the strict physical or mathematical sense. Instead the term is used in the "electrical" sense to refer to two flow passages which provide alternate flow paths between the air inlet and the air outlet.

The apparatus comprises a closed air circulation system in which the humidity of the circulating air is controlled as it passes through the return passage means. Since the circulating air is in a closed system, air is not added to, or removed from, the circulating air to any great extent. Preferably the valve means control the flow of air through said first air flow passage. By allowing or preventing the same air to flow through the first air flow passage, the circulating air has moisture removed from, or added to, it enabling the circulating air to achieve a very

high or a very low humidity.

Preferably the apparatus includes a humidity sensor, conveniently arranged in the main chamber. In this case the valve means can be operated, either automatically or manually, to control the humidity of the air to a desired value.

Preferably the apparatus further comprises air temperature control means and an air temperature sensor. Conveniently the air temperature sensor is arranged in the main chamber and the air temperature control means is conveniently arranged in the air circulating path between the outlet of the main chamber and inlets of the first and second air flow passages. Suitably the temperature control means comprises a solid state device employing resistance heating and Peltier effect cooling.

Conveniently the apparatus includes means for automatically controlling both the temperature and humidity of air in the main chamber. Typically the air in the main chamber can be controlled and maintained at any desired temperature between 10°C and 50°C and at any desired humidity between 5% relative humidity and 95% relative humidity. Suitably the control means includes means for controlling the valve means, circulating means and air temperature control means to achieve a pre-set air temperature and humidity in dependence on the sensed temperature and humidity of the circulating air.

Conveniently the moisture removing means comprises a desiccant, e.g. calcium chloride, arranged within the first air flow passage. The use of a desiccant for removing moisture from the circulating air eliminates the problems caused by condensing excess water from air within a chamber.

Conveniently the moisture adding means comprises water supporting means, e.g. a fabric or the like, positioned within the second air flow passage and water supply means

for supplying water to the water supporting means. Typically the water supporting means is air permeable, is mounted in a frame and extends across the second air flow passage so that air flowing through the second air flow passage passes through the water laden water supporting means. The water supply means may comprise a gravity supply or a mechanical pump such as a syringe pump. The amount of water supplied may be controlled, e.g. by a valve, by starting or stopping a pump or any other suitable means, under the control of said control means.

The valve means suitably comprise valves, e.g. butterfly valves, at both ends of said first air flow passage. In operation, the valve means are normally operated to allow or prevent air to flow through the first air flow passage in dependence on whether it is required to remove or to add moisture from or to the circulating air. Although it is preferred to have valves only controlling air flow through the first air flow passage, other valve arrangements are possible. For example, the second air flow passage could also be provided with valves so that air flow through the second air flow passage could be blocked on flow of air through the first air flow passage. In this case, as an alternative to opening both the first and second flow passages, a valved third air flow passage, in parallel with said first and second air flow passages, could be provided, the third air flow passage being open for air passage therethrough when the first and second air flow passages are closed.

According to another aspect of the present invention there is provided a method of testing an article under different humidity conditions comprising positioning the article in the main chamber of humidity control apparatus according to said one aspect of the present invention, circulating air through said main chamber and said return passage means and automatically controlling said valve means to control the humidity of the circulating air through the main chamber so that the article is subjected to humidity

controlled conditions.

Preferably the temperature of the air is also automatically controlled so that the article is subjected to both humidity and temperature controlled conditions.

Preferably the article comprises footwear which is conveniently positioned on an artificial foot mounted within the main chamber. A typical artificial foot is of the type described in our co-pending UK patent application entitled "An artificial foot" filed on the same date as the present application. In this case, the artificial foot may simulate sweating of a human foot during article testing within the main chamber. In particular the footwear is subjected to controlled sweating and controlled humidity/temperature conditions within the main chamber.

An embodiment of the invention will now be described, by way of example only, with particular reference to the accompanying drawings, in which:

Figure 1 is a schematic sectional view through humidity control apparatus according to the invention,

Figure 2 is a sectional view taken on the line II-II of Figure 1,

Figure 3 is a schematic view on an enlarged scale of moisture adding means of the apparatus shown in Figures 1 and 2, and

Figure 4 is a sectional view taken on the line IV-IV of Figure 3.

Figures 1 and 2 show humidity control apparatus generally designated by the reference numeral 1 comprising a heat insulated housing 2 incorporating a removable, heat insulated cover 3. Within the housing 2 there is provided a main chamber 4, having an air inlet 5 at one end and an

air outlet 6 at its other end, and return passage means for returning air exiting the air outlet 6 to the air inlet 5. The return passage means comprises a first chamber 7 housing an air heating and cooling device 8, a second chamber 9 housing an air circulating fan 10 and air flow passages 11 and 12 arranged in parallel and extending from the first chamber 7 to the second chamber 9. On operation of the air circulating fan 10, air flows in a closed, preferably tightly sealed, path, circulating air passing through the main chamber 4 and being returned to the inlet of the chamber 4 for further circulation via the chamber 7, the air flow passage 12 alone or together with the air flow passage 11, and the chamber 9.

The air heating and cooling device 8 suitably comprises a solid state device, e.g. employing resistance heating and Peltier effect cooling.

The air flow passage 11 has a separate flow control valve 15 at each of its ends. A motorised valve actuator 16 is shown in Figure 2 for moving the valves 15 between a passage open position and a passage closed position. Typically the flow control valves 15 comprise butterfly valves which are operated so as both to be in an open position for allowing air to flow through the passage 11 or so as both to be in a closed position to block or prevent air circulating through the air flow passage 11.

The air flow passage 11 contains a removable desiccant module 20 containing a desiccant, e.g. calcium chloride, for removing moisture from air circulating through the passage 11. If the desiccant becomes laden with water it can be replaced or reprimed.

Within the air flow passage 12 there is positioned a frame 22 carrying a medium 23, such as an air permeable fabric, capable of supporting water. The medium 23 is suitably removably clamped between two separate parts of the frame. Although it is preferred for the medium 23 to

extend across the full cross-section of the passage 12, this is not essential. Indeed if the medium 23 is not a fabric and is not easily air permeable, it should be arranged so that air can pass over its surface instead of through it. The medium 23 is maintained in a moist condition by the supply, via flexible tubing 25, of water from a reservoir (not shown) external to the main chamber and return passage means. The reservoir may merely provide a gravity feed to the medium 23. Alternatively a pump (not shown) may be provided for positively feeding the water from the reservoir to the medium 23. In either case, some sort of control, e.g. a valve (not shown) or control of the pump (if provided), is desirable to control the supply of water to the medium 23.

In order to control the humidity and temperature of the air within the main chamber 4, a humidity sensor 30 and a temperature sensor 40 are arranged in the main chamber 4. The sensors 30 and 40 feed signals to a controller 50 (see Figure 1) for automatically controlling the air heating and cooling device 8, the air circulating fan 10, the valves 15 and possibly also the supply of water to the medium 23. Inputs 60,61 are providing for setting desired values for the temperature and relative humidity of the circulating air.

In use, inputs 60 and 61 are set to desired values and the air is circulated through the main chamber and the return passage means under the automatic control of the controller 50. Depending on the sensed air temperature and air humidity, the controller operates the valves 15 to pass the circulating air through either just the air flow passage 12 or both the air flow passages 11 and 12. It will be realised that, since the cross-sectional area of each passage 11,12 is significantly less than the cross-sectional area of the main chamber, the velocity of air passing either through both passages 11 and 12 or only through the passage 12 will be significantly greater than the velocity of the air as it passes through the main chamber 4 assisting in the

moisturising or drying of the circulating air. Air is circulated throughout the operation of the apparatus even when the desired air temperature and air humidity have been attained. By suitable control of the valves 15, the desired air temperature and air humidity can be maintained at desired values.

The apparatus 1 is primarily intended for testing footwear or socks and an artificial foot 45 is shown in dashed lines in Figure 1 mounted in the main chamber 4. Ideally the artificial foot is of the type described in our co-pending UK patent application entitled "An artificial foot" filed on the same date as the present application and is able to simulate a sweating human foot. The artificial foot described in this co-pending patent application has a body portion with an outer surface, conduit means opening into the outer surface for enabling water to be supplied to parts of the outer surface, and water absorbent material covering at least part of the outer surface of the body portion and all parts where the conduit means open into the outer surface. The water absorbent material preferably comprises an open-cell foam material so that water passed through the conduit means saturates the foam covering and appears on the external surface of the foam material as discrete droplets of water resembling the beads of sweat which form on a human foot as a result of sensible perspiration. By using such an artificial foot 45 in the main chamber 4, footwear and/or socks can be positioned on the artificial foot and can be subjected to varying temperatures/humidity conditions of the circulating air and of the artificial foot. As described in the co-pending UK patent application, the artificial foot may be provided with heating means. This enables full automatic control over humidity and temperature to be achieved during testing of footwear and/or socks.

In other embodiments of the invention the apparatus may be modified. For example instead of using a fully automatic control system, the operation of the fan, air

heating and cooling device and valves may be performed manually in response to the sensed air temperature and air humidity. In other embodiments, the air heating and cooling device, together with the temperature sensors, may be dispensed with.

CLAIMS

1. Humidity control apparatus comprising a main chamber having an air inlet and an air outlet, return passage means connected between said air inlet and said air outlet and comprising at least first and second air flow passages arranged in parallel, circulating means for continuously circulating air through the main chamber and the return passage means, moisture removing means arranged to remove moisture from air circulating through said first air flow passage, moisture adding means for adding moisture to air circulating through said second air flow passage and valve means for controlling the flow of air through said return passage means to control the moisture added to, or removed from, the circulating air.

2. Apparatus according to claim 1, in which the valve means control the flow of air through said first air flow passage.

3. Apparatus according to claim 2, in which the valve control means comprise valves at both ends of the first air flow passage.

4. Apparatus according to any of claims 1 to 3, including a humidity sensor for sensing the humidity of the circulating air.

5. Apparatus according to claim 4, in which the humidity sensor is positioned in the main chamber.

6. Apparatus according to any of the preceding claims, further comprising air temperature control means and an air temperature sensor.

7. Apparatus according to claim 6, in which the air temperature sensor is arranged in the main chamber and the air temperature control means is arranged in the air circulating path between the outlet of the main chamber and

inlets of the first and second air flow passages.

8. Apparatus according to claim 6 or 7, in which the temperature control means comprises a solid state device employing resistance heating and Peltier effect cooling.

9. Apparatus according to claims 6, 7 or 8, each when dependent upon either claim 4 or 5, including control means for automatically controlling both the temperature and humidity of air circulating through the main chamber.

10. Apparatus according to any of the preceding claims, in which the moisture removing means comprises a desiccant arranged within the first air flow passage.

11. Apparatus according to any of the preceding claims, in which the moisture adding means comprises water supporting means positioned within the second air flow passage and water supply means for supplying water to the water supporting means.

12. Apparatus according to claim 11, in which the water supporting means is air permeable and is mounted in a position in which it extends across the second air flow passage so that air flowing through the second air flow passage passes through the water laden water supporting means.

13. Apparatus according to claims 11 or 12, in which the water supply means comprises means for controlling the amount of water supplied to the water supporting means.

14. Humidity control apparatus constructed and arranged substantially as herein described with reference to, and as illustrated in, Figures 1 to 4 of the accompanying drawings.

15. A method of testing an article, e.g. footwear or a sock, under different humidity conditions comprising

positioning the article in the main chamber of apparatus according to any of the preceding claims, circulating air through said main chamber and said return passage means and automatically controlling said valve means to control the humidity of the circulating air through the main chamber so that the article is subjected to humidity controlled conditions.

16. A method according to claim 15, in which the apparatus is according to any of claims 6 to 9 or any of claims 10 to 13 when dependent on claim 6, comprising automatically controlling the temperature of the circulating air.

17. A method according to claim 15 or 16, comprising mounting the article on an artificial foot positioned in the main chamber and capable of delivering water droplets to its outer surface to simulate human perspiration, and controlling the supply of water delivering water droplets to said outer surface as air is circulated through the main chamber.

18. A method according to claim 17, comprising controlling the temperature of the artificial foot as air is circulated through the main chamber.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

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Application number
GB 9221966.6

Relevant Technical Fields

(i) UK Cl (Ed.L) F4V (VFC, VCB, VCF, VCG, VGAB)

(ii) Int Cl (Ed.5) F24F

Search Examiner
A N BENNETT

Date of completion of Search
22 OCTOBER 1993

Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE DATABASES: WPI

Documents considered relevant following a search in respect of Claims :-
1-13, 15-16

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2140912 A	(JAMES) whole document	1,2,4,5,10, 15
X	GB 0969400	(NORMALAIR) whole document	1,15 at least
X	GB 0615567	(BIRLEC) whole document	1-13, 15-16
X	GB 0331824	(GILL) whole document	1,2,4,6, 9-11,13,15, 16

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).